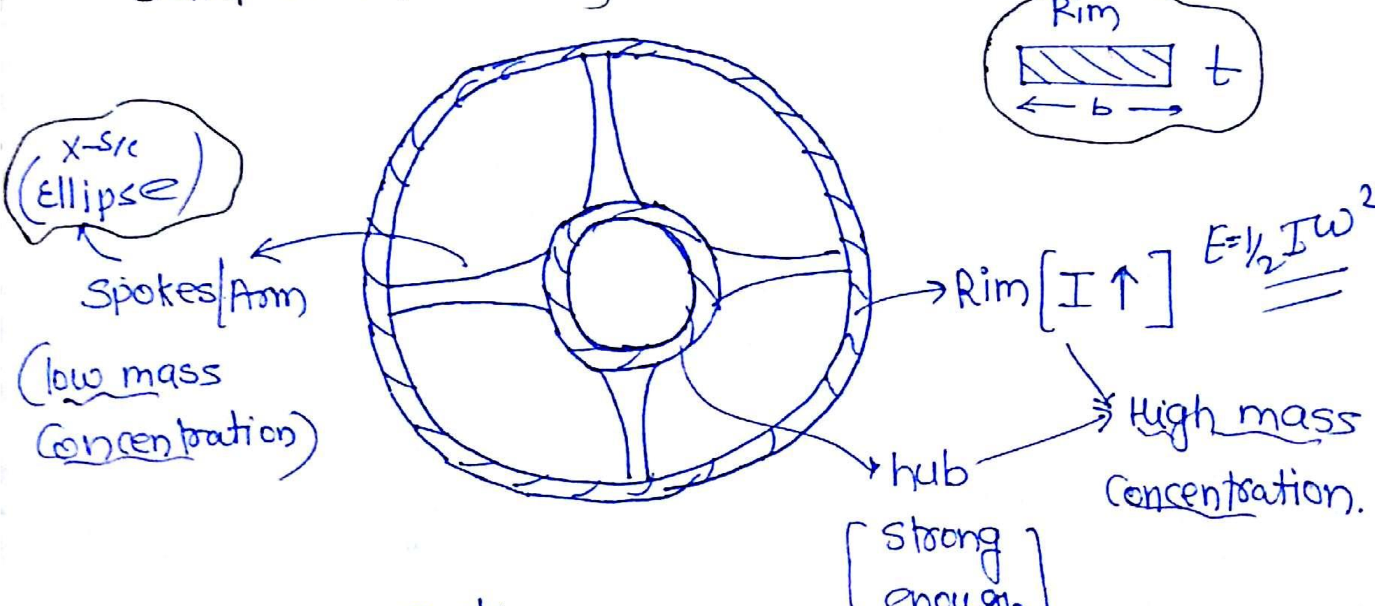
Design of flywheel

Flywheel (energy bank)

Function of Flywheel :-

1. used to store and release energy whenever needed during work cycle.
2. Flywheel is used to reduce motor power in punching press.
3. Flywheel is used to reduce the amplitude of speed fluctuation in IC engine.

Solid one piece flywheel :-

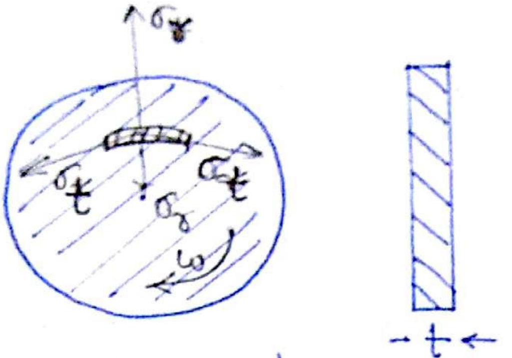


Flywheel → Casting → CI

Problem :- thermal stress due to diff. Cooling rate
↳ sol^n → split Flywheel (Join by cotter)

Best possible Flywheel = Ring

Solid disc Flywheel:-



$$E = \frac{1}{2} I \omega^2$$

Disc 'R'

ρ = density

m = mass

$$I = \frac{mR^2}{2}$$

$V = r\omega$

μ = poisson ration

$\mu_{CI} = 0.27 - 0.3$

There are two type of principle stress induced at any Generalised small radius 'r'

σ_t = tengential stress

σ_r = Radial stress.

$$\sigma_t = \frac{\rho V^2(\mu+3)}{8}\left[1 - \left(\frac{3\mu+1}{\mu+3}\right)\left(\frac{r}{R}\right)^2\right]$$

$$\sigma_r = \frac{\rho V^2(\mu+3)}{8}\left[1 - \left(\frac{r}{R}\right)^2\right]$$

when $r = 0 \Rightarrow \sigma_t = \sigma_r = \sigma_{max}$

$$\boxed{\sigma_{max} = \frac{\rho V^2(\mu+3)}{8}}$$

safe Cond^n

$$\sigma_{max} \leq \sigma_{per}$$

$$\frac{\rho V^2 (\mu + 3)}{8} \leq \sigma_{per}$$

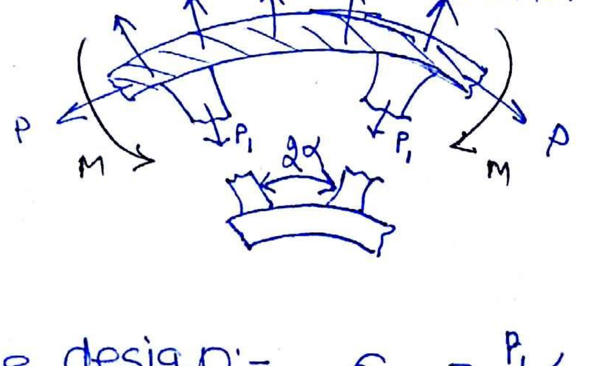
$$V \leq \sqrt{\frac{8\,\sigma_{per}}{\rho(\mu+3)}}$$

$$\boxed{V_{max} = \sqrt{\frac{8\,\sigma_{per}}{\rho(\mu+3)}}}$$

$$\boxed{\omega_{max} = \frac{V_{max}}{R}}$$

$$E_{max} = \frac{1}{2} I \omega_{max}^2$$

Rimmed flywheel design:-



A_1 = Spoke area

$$A_1 = \pi \left(\text{Semi major}\right)\left(\text{Semi minor}\right)$$

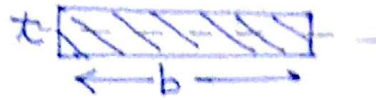
Spoke design:- $\sigma_{ind} = P_1/A_1$

safe Cod^n $\sigma_{ind} \leq \sigma_{per}$

$$\boxed{P_1/A_1 \leq \sigma_{per}}$$

bending due to spoke (P_1)

rim design



$A = b \cdot t$

$$\sigma_{max} = \frac{P}{bt} + \frac{M \cdot t/2}{bt^3/12}$$

$$\sigma_{max} = \frac{P}{bt} + \frac{6M}{bt^2}$$

Safe cond^n

$$(\sigma_b)_{max} \le \sigma_{per.}$$

$$\frac{P}{bt} + \frac{6M}{bt^2} \le \sigma_{per.}$$

* $P_1 = \frac{2}{3} \frac{m' v^2}{C}$, m' = mass per unit length (kg/m) $m' = m/\pi D$

$$C = 12 \frac{R^2}{t^2}(x) + y + \frac{A}{A_1}$$

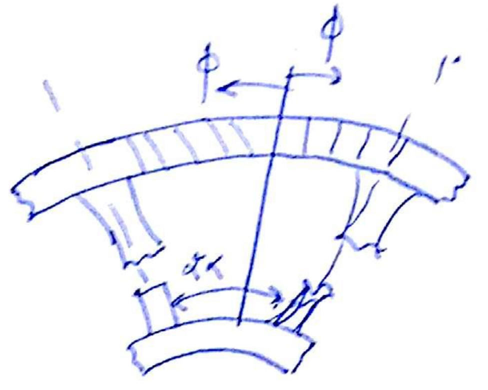
$$x = \frac{1}{2\sin^2\alpha}\left[\frac{\sin 2\alpha}{4} + \frac{\alpha}{2}\right]$$

$$y = \frac{1}{2\sin^2\alpha}\left[\frac{\sin 2\alpha}{4} + \frac{\alpha}{2}\right] - \frac{1}{2\alpha}$$

$$M_{at\,\phi} = \frac{P_1 R}{2}\left[\frac{\cos\phi}{\sin\phi} - \frac{1}{\alpha}\right]$$

$$P_{at\,\phi} = m'v^2 - \frac{P_1 \cos\phi}{2\sin\alpha}$$

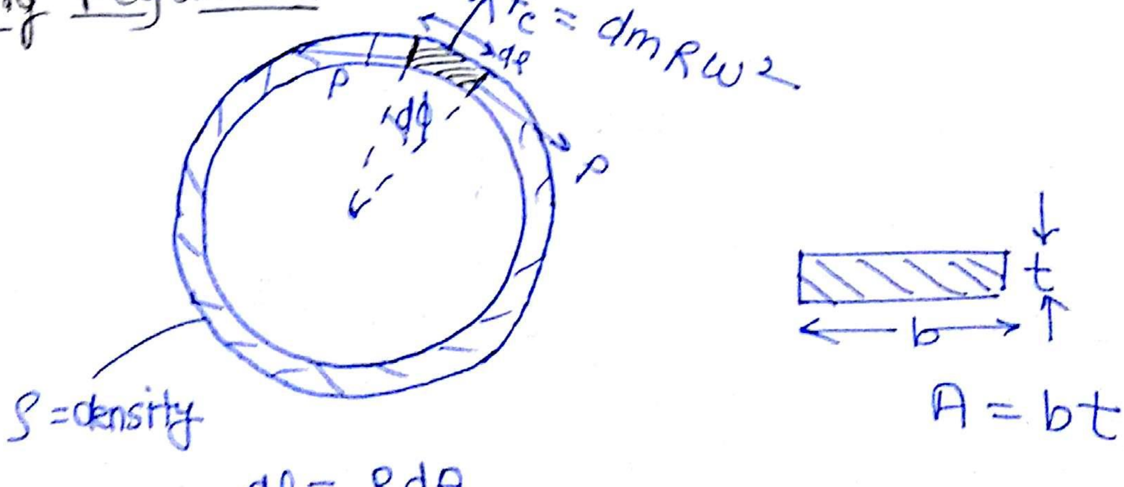
2α = Angle b/w 2 spokes.



$\phi_{max} = \alpha$

If the spokes are neglected

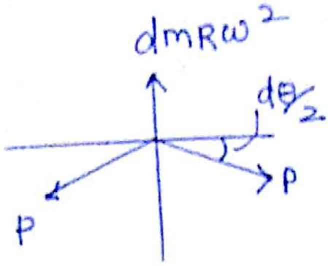
<u>Ring Flywheel</u>



$A = bt$

$dl = R\,d\theta$

$dm = \rho A\,dl = \rho A(R\,d\theta)$



$$dm R\omega^2 = 2P \sin\frac{d\theta}{2}$$

$$(\rho A R d\theta) R\omega^2 = P\, d\theta$$

$$\rho A R^2 \omega^2 = P$$

$$\frac{P}{A} = \rho R^2 \omega^2 = \rho V^2$$

V = Velocity

$$\sigma_{ind} = \rho V^2$$

Safe Condⁿ

$$\sigma_{ind} \le \sigma_{per.}$$

$$\rho V^2 \le \sigma_{per.}$$

$$\boxed{V_{max} = \sqrt{\frac{\sigma_{per}}{\rho}}}$$

$$\boxed{\omega_{max} = \frac{V_{max}}{R}}$$

$$\boxed{E_{max} = \frac{1}{2} I \omega_{max}^2}$$